

TRENDS IN NATIONAL R&D SUPPORT

R&D expenditures in the United States are expected to reach \$220.6 billion in 1998.⁴ This amount implies a nominal growth rate (without accounting for inflation) of 7.3 percent over the 1997 preliminary level of \$205.6 billion, or a real-growth rate (after adjusting for expected inflation) of 5.3 percent.⁵ The 1997 level of R&D reflects a 4.9-percent nominal growth over \$196.0 billion spent in 1996, or 2.8-percent real growth.

The Gross Domestic Product, the main measure of the nation's total economic activity, grew in real terms by 2.7 percent in 1998, and 3.8 percent in 1997, by preliminary

estimates, growing faster than R&D in 1997, but slower than R&D in 1998. Since 1994, however, R&D has generally been outpacing the overall growth of the economy, thereby becoming a larger component of the economy—from 2.43 percent of GDP in 1994 to 2.61 percent in 1998.

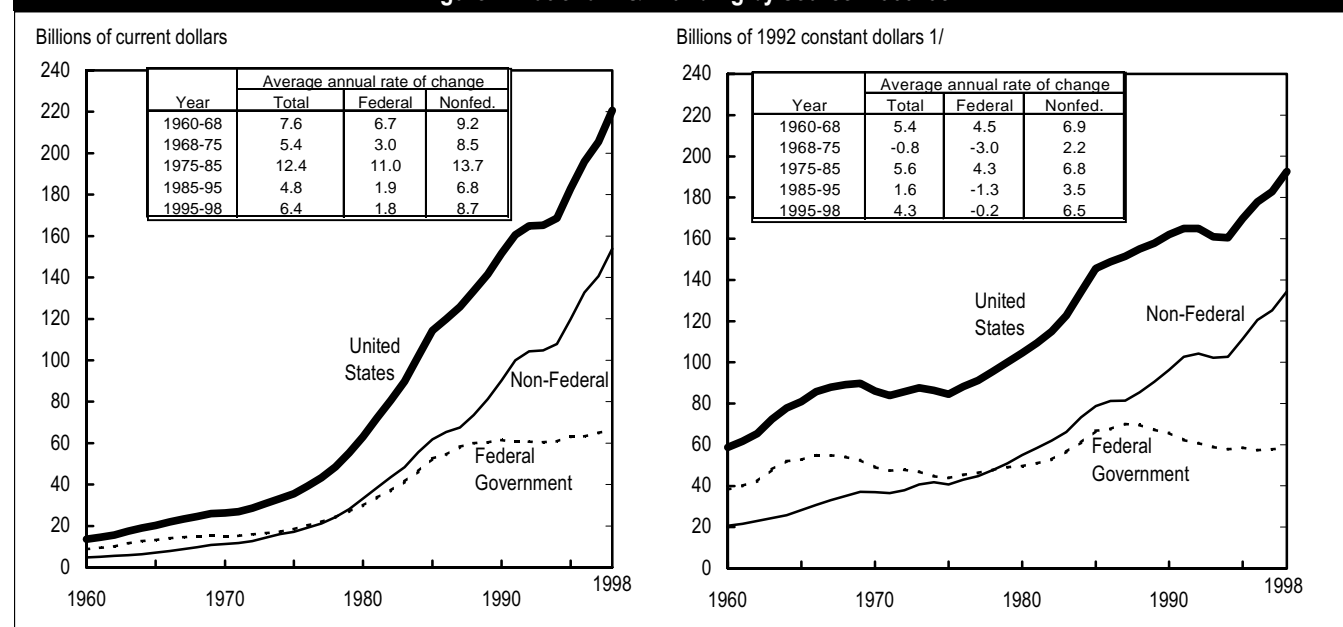
In 1998, the Federal Government is expected to provide 30.2 percent (\$66.6 billion dollars) of total projected funds for R&D; industry will supply 65.1 percent (\$143.7 billion in current dollars), and the remaining sectors of the economy, i.e., state governments, universities and colleges, and other nonprofit institutions, will contribute 4.7 percent (\$10.3 billion).

Starting in 1969 and for nearly a decade thereafter, R&D growth failed to keep up with either inflation or general increases in economic output. In fact, between 1968 and 1975, real R&D expenditures declined 5 percent, due to both business and government de-emphasizing funding for research programs (figure 2). Federal funding in particular fell considerably during this period (down 19 percent in real terms). Both Federal defense- and nondefense-related R&D programs declined.

⁴ Except for discussions of the Federal budget authority, which are in reference to fiscal years, other references to years in this report are with respect to calendar years, not fiscal years, even in discussions on academic and Federal intramural performance. Other NSF reports on academic or Federal expenditures alone, however, refer to fiscal years, because those institutions operate on a fiscal year basis. Calendar years are used in the *National Patterns* report, however, for consistency with industry data, which represent the largest share of U. S. R&D expenditure, and for consistency with the vast majority of all other national economic statistics provided by Federal statistical agencies.

⁵ For a discussion about how dollar amounts are adjusted for inflation in this report, see Appendix A: Controlling for Inflation and Foreign Currency.

Figure 2. National R&D funding by source: 1960–98



1/ Based on GDP implicit price deflator.

NOTE: Data are preliminary for 1997 and 1998.

SOURCE: National Science Foundation/Division of Science Resources Studies, table B-1A.

Following an economic recovery from the 1974 oil embargo and the 1975 recession, a significant funding reversal occurred. U.S. R&D expenditures increased in real terms by approximately 72 percent from 1975–85, compared with a 37-percent rise in real GDP over the same period.

During the first half of this period (1975–80), there was considerable growth in Federal R&D funding for nondefense activities. Although defense-related R&D expenditures rose annually, much of the Federal R&D gain was attributable to energy-related R&D (particularly nuclear energy development) and to greater support for health-related R&D. Non-federal R&D increases were concentrated in industry and resulted largely from greater emphasis on energy conservation and improved use of fossil fuels. Consequently, energy concerns fostered increases in R&D funding by both Federal and non-federal sources. Support for energy R&D rose over 150 percent in real terms between 1974 and 1979 and accounted for approximately one-half of the national increase in real R&D spending.

Overall, the U.S. constant-dollar investment in total R&D grew at an average annual rate of 4.4 percent during 1975–80. Although the rate of increase remained rather steady through 1982 (between 4 and 5 percent annually), the focus of the national R&D effort began to shift heavily toward defense-related activities in the early eighties. Largely as a result of increases in defense R&D, growth in real R&D expenditures accelerated to an average annual rate of 8.2 percent over 1982–85: not since the space-inspired spending thrust in the early sixties had R&D in the United States grown so rapidly during any 3-year period. On average, from 1980–85, R&D spending increased 6.8 percent per year in real terms.

This pattern of a generally increasing rate of real R&D growth, however, changed abruptly in the mid-eighties and continued through the early nineties. From 1985–94, R&D spending slowed to a 1.1-percent annual real rate of increase, in comparison to a 2.4-percent annual real growth in GDP. Some slackening of both Federal and non-federal funding of R&D, as a proportion of GDP, had contributed to this slowing. However, it is primarily the decline in real Federal R&D funding, as reported by R&D performers, that contributed to the slow growth of R&D in the early nineties.⁶

⁶ In recent years, increasing differences have been detected in data on federally financed R&D as reported by Federal funding agencies, on the one hand, and by performers of the work (federal labs, industry, universities, and other nonprofit organizations), on the other hand. This divergence in R&D totals is discussed in Appendix A.

The downward trend was then reversed in 1994, caused by substantial increases in industrial R&D.⁷ By preliminary estimates, U.S. R&D grew in real terms by 4.7 percent per year between 1994 and 1998, in spite of virtually no real growth (0.2 percent) in Federal R&D support. Over the same period, industrial support for R&D grew at a real annual rate of 7.3 percent, by preliminary calculations. Much of this increase might be explained by the favorable economic conditions that generally existed over the past 4 years.

TRENDS IN FEDERAL SUPPORT

As a share of the national R&D total, Federal Government funding has continued to decline in recent years. Though it was previously the primary provider of the Nation's R&D funds, the Federal Government's share of R&D funding first fell below 50 percent in 1979. From 1980–88, the Federal Government provided between 44 and 47 percent, but has fallen systematically since that time. The preliminary Federal R&D funding in 1998, \$66.6 billion, represents a 0.8-percent increase from the preliminary 1997 level in real terms. Consequently, due to the notable increase in industrial support, the Federal Government's estimated share of R&D support for 1998, 30.2 percent, is the lowest ever recorded in the data series (which begins in 1953).⁸

Even with its declining share of the national total, Federal R&D funding did expand between 1980 and 1998 (from \$29.9 to \$66.6 billion), which, after inflation, amounted to a small, real growth rate of 0.9 percent per year. This rate, however, was not at all uniform across the period. From 1980–85, Federal R&D funding grew on average by 6.2 percent in real terms annually. Support then slowed considerably in 1986, reflecting the budgetary constraints imposed on all government programs, including those mandated by the Balanced Budget and Emergency Deficit Control Act of 1985 (also known as the Gramm-Rudman-Hollings Act) and subsequent legislation (notably the Budget Enforcement Act of 1990, which legislated

⁷ For a detailed discussion of this upturn, see Jankowski, J., "R&D: The Foundation for Innovation . . . Changes in U.S. Industry," in *Trends in Industrial Innovation: Industry Perspectives and Policy Implications*, Sigma Xi, The Scientific Research Society, Inc., Research Triangle Park, NC, 1998, pp. 201–211.

⁸ The sample design for estimating industry R&D expenditures was revised for 1991 and later years. The effect of the change in industry's sample design was to reduce the Federal share of the national R&D total to 38 percent in 1991, down from the 41-percent share previously published for 1991. See appendix A for more information on these survey changes and their impact on the R&D estimates.

that new spending increases be offset with specific spending cuts). Since then, the Federal R&D data reflect the government's growing emphasis on deficit reduction and a shift in the balance between defense and domestic programs. As a consequence, real Federal R&D support has declined on average by 1.1 percent per year over 1985–98, by preliminary calculations.

Nearly all the rise in Federal R&D funding during the early eighties was due to large increases in defense spending, as evidenced by the figures on the Federal budget authority (figure 3). For example, defense activities of the Department of Defense (DoD) and the Department of Energy (DOE) accounted for roughly one-half of total Federal R&D budget authorizations in 1980.⁹ By 1986, such defense-related activities peaked at 69 percent of the Federal R&D budget authority.

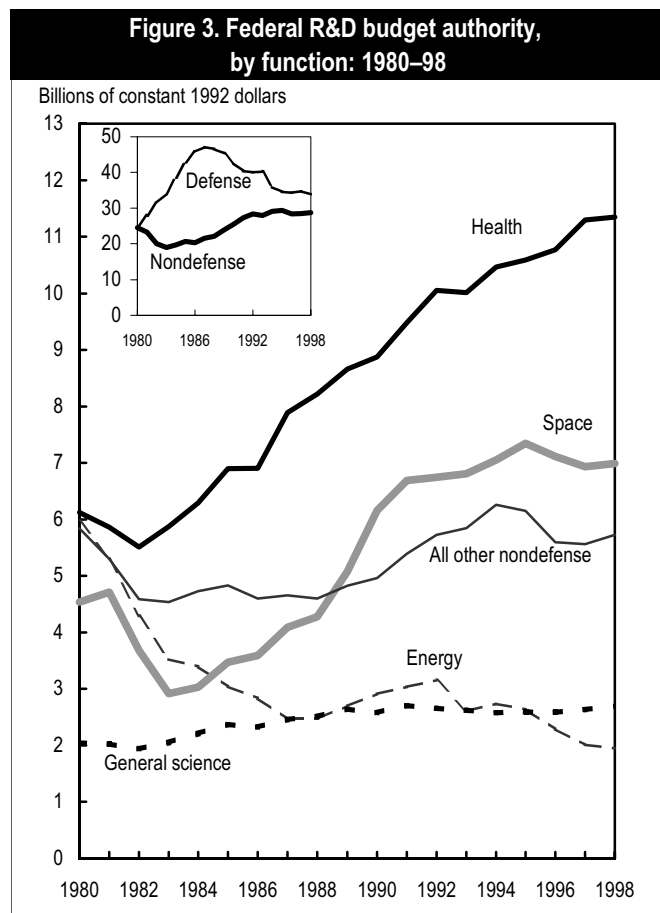
⁹ These percentage share calculations of defense-related R&D activities are based on Federal budget authorization totals, not on data reported by the performers of R&D.

After 1986, Federal R&D spending priorities shifted, resulting in part from additional budgetary pressures and from modifications in U.S. security measures in an evolving international arena. Thus, the defense buildup in the early and mid-1980s was followed by a period of moderate reductions in the late 1980s, a leveling of R&D spending in the early 1990s, and a return to planned, moderate reductions in the mid-1990s. Since 1986, Federal budget authority for civilian-related R&D grew faster than defense-related R&D. In particular, the budget allocation for health- and space-related R&D increased substantially between 1986 and 1998, with average real annual growth rates of 4.6 and 6.0 percent, respectively, using preliminary figures for 1998. (As indicated in figure 3, most of this growth in the budget authority for space-related R&D occurred between 1986 and 1991.) The budget allocation for defense programs declined by an average real annual rate of 2.3 percent during the same period. As a result, in 1998, defense-related R&D accounts for an estimated 54.1 percent of the 1998 total Federal R&D budget authority, in contrast to 69.3 percent for 1986.

Based on preliminary figures, R&D accounts for 15 percent of the Federal defense-related budget authority for 1998, and 3 percent of the Federal nondefense authority (table 1). In nondefense areas, R&D accounts for 75 percent of general science funds, nearly all of which (94 percent) is devoted to basic research (table 2). R&D accounts for 67 percent of funds for space research and technology, most of which (61 percent) is devoted to development. Among funds for health, R&D represents 10.0 percent, most of which (54 percent) is devoted to basic research, and nearly all of which (95 percent) is directed toward programs of the National Institutes of Health (NIH).

In the area of energy, the Department of Energy actually registers a negative total budget authority because of offsetting receipts received from sales of the Strategic Petroleum Reserve. Consequently, the concept of R&D expenditure as proportion of total budget authority would not be meaningful in this case.

At first glance, the R&D budget authority for energy appears to have declined rapidly, from \$2.4 billion in 1997 to only \$1.1 billion (by preliminary estimates) in 1998. However, this effect is not an actual decline in economic resources devoted to energy R&D, but merely the result of reclassification. Specifically, beginning in FY 1998 several DOE programs were reclassified from “energy” to “general science,” so that the \$1.3 billion drop from \$2.4 to \$1.1 billion in energy R&D was equally offset by



NOTES: The larger graph pertains to nondefense R&D only. Data are preliminary for 1997 and 1998.

SOURCE: National Science Foundation/Division of Science Resources Studies; table B-10.

Table 1. R&D as a percentage of Federal budget authority, by function: FY 1998

Budget function	R&D total (preliminary 1998)	Federal total	R&D share
	[Billions of dollars]		[Percent]
Total	73.639	1,687.308	4.4
On-budget.....	73.639	1,364.917	5.4
National defense.....	39.871	267.560	14.9
Nondefense (on-budget).....	33.768	1,097.357	3.1
Health.....	13.557	135.031	10.0
Space research and technology.....	8.265	12.312	67.1
Energy 1/.....	1.143	(0.384)	NA
General science.....	4.210	5.642	74.6
Natural resources and environment.....	2.015	24.356	8.3
Transportation.....	1.920	42.979	4.5
Agriculture.....	1.243	10.591	11.7
All other.....	1.415	866.830	0.2

1/ The budget authority for Energy is negative because of offsetting receipts from sales of the Strategic Petroleum Reserve.

KEY: NA = Not applicable

NOTES: Because of rounding, components may not add to the totals shown. Data are derived from the administration's 1999 budget proposal. On-budget totals are for all Federal Government transactions except those of the social security trust funds (Federal Old-Age and Survivors Insurance and Federal Disability Insurance Trust Funds) and the Postal Service.

SOURCES: National Science Foundation/Division of Science Resources Studies, and Office of Management and Budget, *The Budget for Fiscal Year 1999*, Historical Tables, and National Science Foundation/Division of Science Resources Studies, *Federal R&D Funding by Budget Function: Fiscal Years 1997–99*, NSF 99-315.

a \$1.3 billion rise in general science from \$2.9 billion to \$4.2 billion. (See appendix table B-10.)

For the Nation as a whole, defense-related R&D climbed from 24.2 percent of the total R&D effort in 1980 to 31.8 percent in 1987. In 1998, defense-related R&D fell to 16.4 percent of total R&D expenditures, according to preliminary findings (figure 4). These shares by national objective represent a distribution of performer-reported R&D data. They are distinct from the budget authority shares reported above that are based on the various functional categories that comprise the Federal budget. (See appendix A).

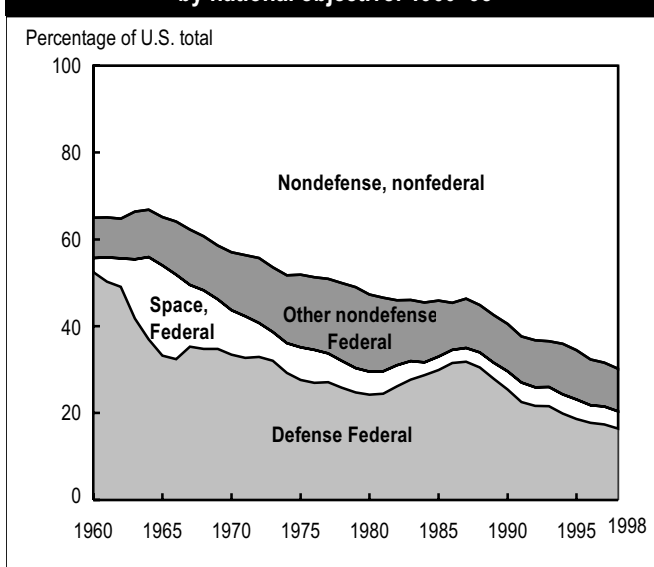
Table 2. Budget authority for R&D by function and character of work: Anticipated levels for FY 1998

Budget function	Basic research	Applied research	Develop- ment	R&D total
	[Millions of dollars]			
Total	15,710	15,570	42,359	73,639
National defense.....	1,099	4,308	34,463	39,871
Nondefense (total).....	14,611	11,261	7,895	33,768
Health.....	7,361	4,618	1,578	13,557
Space research and technology.....	1,658	1,591	5,015	8,265
Energy.....	257	370	516	1,143
General science.....	3,944	266	0	4,210
Natural resources and environment.....	156	1,667	191	2,015
Transportation.....	459	1,258	203	1,920
Agriculture.....	560	589	94	1,243
All other.....	216	902	297	1,415

NOTE: Because of rounding, components may not add to the totals shown.

SOURCES: National Science Foundation/Division of Science Resources Studies, *Federal R&D Funding by Budget Function: Fiscal Years 1997–99*, NSF 99-315, and unpublished tabulations.

Figure 4. R&D spending as a percentage of total, by national objective: 1960–98



NOTES: All industry-funded R&D is classified as civilian R&D, including outlays by aerospace and electronic industries. Data are preliminary for 1997 and 1998.

SOURCE: National Science Foundation/Division of Science Resources Studies; table B-9.

Space-related R&D funding, as a percent of total R&D funding, had reached a peak of 20.8 percent in 1965, during the height of U.S. efforts to exceed the Soviet Union in space travel. It has declined steadily since that time, to a low of 3.0 percent in 1984 and 1986. By 1990 it was back up to 4.2 percent and has remained between 4.0 and 4.5 percent since that time. Federal support for “civilian-related” R&D (nondefense-nonspace programs), as a percent of total U.S. R&D, has been declining steadily since 1994, when it was 11.7 percent. It is expected to be 9.8 percent in 1998, the lowest since 1962 (when it was 9.1 percent).

Preliminary estimates of Federal R&D obligations for 1998 indicate that seven Federal agencies have R&D obligations of over \$1 billion, out of the total Federal R&D obligations of \$69.8 billion. These are, in descending order of R&D obligations: DoD (with a 48.7 percent share of the total), HHS (18.8 percent), NASA (13.3 percent), DOE (8.1 percent), NSF (3.4 percent), USDA (2.0 percent), and the Department of Commerce (DOC) (1.5 percent) (table 3).

In contrast to total R&D obligations, only three agencies have intramural R&D expenditures that exceed

Table 3. Preliminary Federal R&D obligations, total and intramural by agency: FY 1998

Agency	Total R&D obligations (millions of current dollars)	Total R&D obligations as a share of Federal total (percent)	Intramural R&D (millions of current dollars)	Percent of agency R&D obligations that are intramural 1/	Percent change in real intramural R&D from previous year 2/
Department of Defense.....	34,030.4	48.7	7,698.8	22.6	-12.9
Department of Health & Human Services.....	13,127.4	18.8	2,872.3	21.9	0.5
National Aeronautics & Space Administration.....	9,272.0	13.3	2,318.0	25.0	1.2
Department of Energy.....	5,636.3	8.1	636.9	11.3	28.4
National Science Foundation.....	2,346.9	3.4	17.9	0.8	-3.0
Department of Agriculture.....	1,376.0	2.0	937.0	68.1	-0.5
Department of Commerce.....	1,035.9	1.5	705.2	68.1	-3.2
Department of Transportation.....	666.1	1.0	202.4	30.4	20.9
Department of the Interior.....	595.6	0.9	521.9	87.6	1.5
Environmental Protection Agency.....	553.9	0.8	282.5	51.0	7.8
Department of Veterans Affairs.....	240.3	0.3	238.7	99.3	-14.5
Agency for International Development.....	225.0	0.3	25.6	11.4	34.3
Department of Education.....	225.5	0.3	9.6	4.3	7.1
Smithsonian Institution.....	132.0	0.2	132.0	100.0	0.4
Tennessee Valley Authority.....	44.0	0.1	44.0	100.0	-31.1
Nuclear Regulatory Commission.....	53.9	0.1	13.5	25.0	1.9
Department of Labor.....	38.0	0.1	18.1	47.6	-0.2
Department of Justice.....	85.2	0.1	40.5	47.5	-3.1
Department of the Treasury.....	52.9	0.1	39.2	74.1	-1.4
Department of Housing & Urban Development.....	39.5	0.1	24.8	62.8	18.7
Social Security Administration.....	37.1	0.1	5.1	13.7	257.5
US International Trade Commission.....	6.0	0.0	6.0	100.0	1.5
Library of Congress.....	11.7	0.0	11.7	100.0	16.0
Department of State.....	0.8	0.0	0.3	37.5	-1.9
Other Agencies 3/.....	6.0	0.0	4.4	73.3	-8.1
Entire Federal Government 4/.....	69,838.4	100.0	16,806.5	24.1	-5.4

1/ Intramural activities include actual intramural R&D performance and the costs associated with the planning and administration of both intramural and extramural programs by Federal personnel. For the definition of intramural performers, see Definitions for Classification and Measurement, in appendix A.

2/ Based on fiscal year GDP implicit price deflators for 1997 and 1998 (table B-5).

3/ Includes: Appalachian Regional Commission, Consumer Product Safety Commission, Federal Communications Commission, Federal Trade Commission, National Archives and Records Administration, US Arms Control and Disarmament Agency, and US Information Agency.

4/ Numbers do not total exactly, due to rounding.

SOURCE: National Science Foundation/Division of Science Resources Studies, Survey of Federal Funds for Research and Development: Fiscal Years 1996, 1997, and 1998.

\$1.0 billion in 1998, including costs associated with planning and administering extramural R&D programs: DoD, HHS (which includes NIH), and NASA.¹⁰ These three agencies, together, account for 80.8 percent of all Federal R&D obligations for 1998, and 76.7 percent of Federal intramural R&D, by preliminary tabulations.

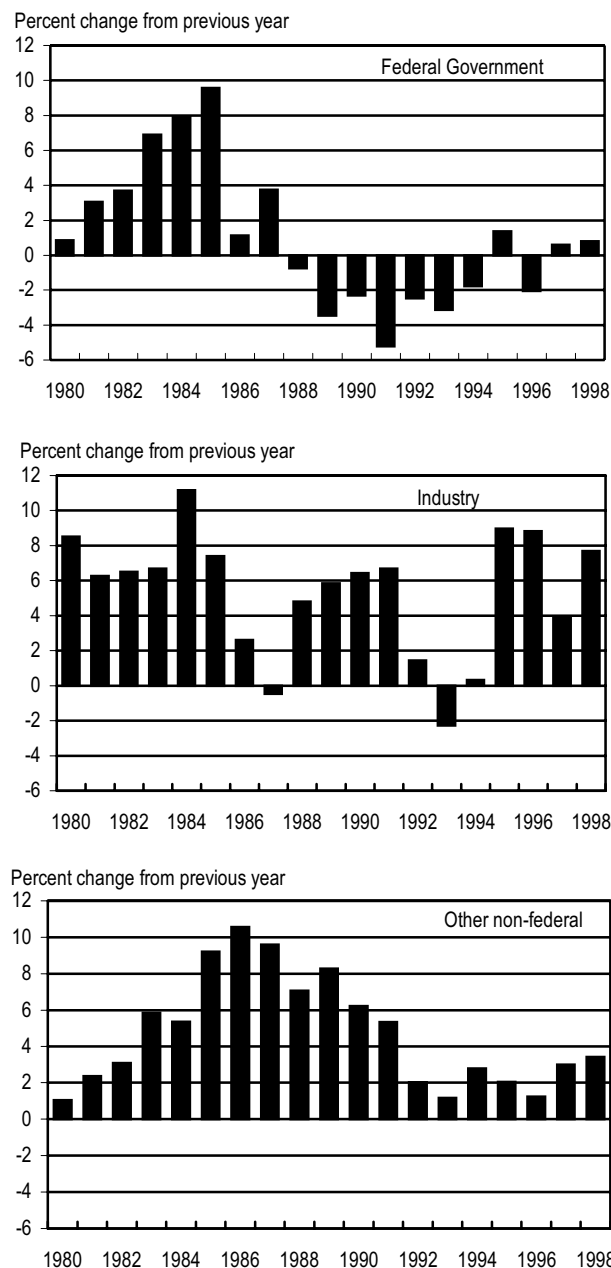
TRENDS IN NON-FEDERAL SUPPORT

Between 1980 and 1985, concurrent with gains in Federal R&D spending, R&D support from non-federal sources grew substantially—by 7.4 percent per year after inflation. It then slowed to 4.1 percent between 1985 and 1990, and 2.9 percent between 1990 and 1995, but is expected to be back up to 6.5 percent for the 1995–98 period.

Most non-federal R&D support is provided by industry. Of the projected 1998 non-federal total (\$154.0 billion), 93.3 percent (\$143.7 billion) is company funded, representing a 7.7-percent increase over its 1997 level in real terms. Industry's share of national R&D funding first surpassed that of the Federal Government in 1980, and it has remained higher ever since. From 1980–85 industrial support for R&D, in real dollars, grew at an average annual rate of 7.6 percent. This growth was maintained through both the mild 1980 recession and the more severe 1982 recession (figure 5). Key factors behind increases in industrial R&D included a growing concern with international competition, especially in high-technology industries; the increasing technological sophistication of products, processes, and services; and general growth in defense-related industries such as electronics, aircraft, and missiles.

Between 1985 and 1994, growth in R&D funding from industry was slower, averaging only 2.8 percent per year in real terms. This slower growth in industrial R&D funding was only slightly greater than the real growth of the economy over the same period (in terms of real GDP), which was 2.4 percent. In contrast, from 1994–98, by preliminary estimates, it grew in real terms by 7.3 percent per year, compared with a 2.8 percent for the economy overall.

Figure 5. Annual changes in national R&D spending, by source of funds: 1980–98 (based on constant 1992 dollars)



NOTE: Data are preliminary for 1997 and 1998.

SOURCE: National Science Foundation/Division of Science Resources Studies; table B-1B.

¹⁰ Estimates are for FY 1998 Federal intramural obligations as reflected in the administration's 1998 budget proposal (see appendix A) and cover costs associated with planning and administering intramural and extramural R&D programs by Federal personnel, as well as actual intramural R&D performance. See NSF, *Federal Funds for Research and Development: Fiscal Years 1996, 1997, and 1998*, NSF 98-332.

As one might expect, however, growth of industrial R&D varies significantly among different industrial sectors.¹¹ The industrial sectors with the largest annual growth in real R&D performance, from non-federal sources, between 1986 and 1996, have been: non-manufacturing¹² (16.2 percent); lumber, wood products, and furniture (12.4 percent); paper and allied products (7.6 percent), and electrical equipment (4.3 percent). Those industries experiencing the greatest annual declines (or negative growth) in R&D over the same period were: stone, clay, and glass products (-9.7 percent); primary metals (-5.1 percent); petroleum refining and extraction (-4.9 percent); and food, kindred, and tobacco products (-1.1 percent) (table 4).

R&D funding from other non-federal sectors—namely academic and other nonprofit institutions, including the support they receive from state and local governments—has been more consistent over time. It grew in real terms at average annual rates of 5.2 percent between

¹¹ For studies of patterns of technological change among different industrial sectors, see, for example, Nelson, R. "Recent evolutionary theorizing about economic change," *Journal of Economic Literature*, 33, 1:48-90, 1995; Pavitt, K., "Sectoral patterns of technological change: Towards a taxonomy and a theory," *Research Policy*, 13:343-373; Payson, S., "Product Evolution and the Classification of Business Interest in Scientific Advances," *Knowledge and Policy*, Vol. 9, No. 4, 1996-97; and Utterback, J.M., "The dynamics of product and process innovation in industry," in C.T. Hill & J.M. Utterback, eds., *Technological innovation for a dynamic economy*, New York: Pergamon Press: 1979.

¹² See appendix A, the section on "Use of 'Nonmanufacturing' as a Single Industrial Category." Further, as a result of recent improvements (since 1992) in the NSF sampling of firms located in the service sector, it is not clear to what extent the nonmanufacturing sector has rapidly expanded its share of the Nation's R&D, or how much of the apparent increase is due solely to improved measurement techniques.

1980 and 1985, 8.3 percent between 1985 and 1990, 2.7 percent between 1990 and 1995, and, by preliminary calculations, 2.5 percent between 1995 and 1998. The projected \$10.3 billion in funding in 1998 is 3.4 percent higher in real terms than its preliminary 1997 level. Most of these funds have been used for research performed within the academic sector.

Table 4. Change in non-federal funds for industrial R&D, by industry, 1986 and 1996

Industry	SIC code(s)	R&D		Average annual real growth in R&D
		1986	1996	
		[Millions of dollars]		[Percent]
Other manufacturing industries 1/.....	27,31,39	380	2,423	16.64
Nonmanufacturing industries 1/.....	--	4,740	29,170	16.23
Lumber, wood products, and furniture.....	24,25	144	634	12.40
Paper and allied products.....	26	538	1,534	7.62
Electrical equipment.....	36	9,767	20,356	4.30
Chemicals and allied products.....	28	8,664	17,520	3.99
Rubber products.....	30	655	1,269	3.54
Professional and scientific instruments.....	38	4,752	8,207	2.36
Textiles and apparel.....	22,23	246	414	2.10
Fabricated metal products.....	34	800	1,322	1.91
Transportation equipment.....	37	13,567	20,535	1.02
Machinery.....	35	10,701	13,338	-0.92
Food, kindred, and tobacco products.....	20,21	1,280	1,564	-1.12
Petroleum refining and extraction.....	13,29	1,971	1,630	-4.91
Primary metals.....	33	786	637	-5.10
Stone, clay, and glass products.....	32	941	463	-9.72

1/ Due to revisions in survey methodology, statistics for "Other manufacturing industries" for 1996 are not comparable with statistics for prior years.

SOURCE: National Science Foundation/Division of Science Resources Studies, Research and Development in Industry 1995-96, NSF 99-312